AD

463 918

This material published by the Clearinghouse for Federal Scientific and Technical Information is for use by the public and may be reprinted except that where patent questions appear to be involved the usual preliminary search is advised, and where copyrighted material is used permission should be obtained for its further publication.

CLEARINGHOUSE
FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION
OF THE
U.S. DEPARTMENT OF COMMERCE

Best
Available
Copy

U.S. ARMY

Technical Memorandum 16-64

THE EFFECTS OF CONFINEMENT ON THE PERFORMANCE OF COMBAT RELEVANT SKILLS: SUMMARY REPORT

Samuel A. Hicks

December 1964

AMCMS Code 5014.11.841

HUMAN ENGINEERING LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

2.00 — 44

DDC Availability Notice

QUALIFIED REQUESTERS may obtain copies of this report from DDC.

~~AD63049~~
PB169808

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.
Use of trade names in this report does not constitute an official indorsement or approval of the use of such commercial products.

AMCMS Code 5014.11.841 Technical Memorandum 16-64

THE EFFECTS OF CONFINEMENT ON THE PERFORMANCE OF COMBAT RELEVANT SKILLS: SUMMARY REPORT

Samuel A. Hicks

December 1964

APPROVED: John D. Weisz
JOHN D. WEISZ
Technical Director
Human Engineering Laboratories

U. S. ARMY HUMAN ENGINEERING LABORATORIES
Aberdeen Proving Ground, Maryland

ABSTRACT

This report summarizes the results of the U. S. Army Human Engineering Laboratories program on confinement in Armored Personnel Carriers. The report relates individual studies to one another and discusses the results as they apply to the goals of the overall program. Vehicle design deficiencies are cited and discussed.

CONTENTS

TABLES

THE EFFECTS OF CONFINEMENT ON THE PERFORMANCE OF COMBAT RELEVANT SKILLS: SUMMARY REPORT

INTRODUCTION

Troops fighting fast-moving future wars under the threat of Nuclear-Bacteriological-Chemical (NBC) attack may have to live in and fight from armored vehicles for long periods of time. It is important, therefore, to know how long troops can endure the environmental conditions imposed on them by confinement in Armored Personnel Carriers (APCs) without suffering a loss in their combat efficiency. The Human Engineering Laboratories initiated an extended study of this question in January 1960.

The general problem was first reduced to its smallest components. A subjective appraisal suggested that the following variables may significantly affect the behavior of troops confined in APCs for long periods:

a. Temperature extremes

b. Vibration

c. Blast effects (acceleration and deceleration)

d. High ambient-noise level

e. Body restriction (cramping)

f. Air pollution

g. Sleep deprivation

h. Forced alteration of the diurnal cycle

Since no one knows precisely how any of these variables affect behavior individually, and since there may be other variables involved but not yet identified, a single complex variable -- confinement -- was defined and studied as it influenced the performance of armored-infantry personnel. Operationally defined, confinement provides a generally monotonous sensory situation that may deprive some sensory channels of stimulation and stimulate others excessively. In addition, limited overt behavioral alternatives are usually present.

This definition may seem to place this research within the framework of psychological research on isolation and sensory deprivation. However, closer examination reveals that confinement is not only different, it is unique. In the classical studies of sensory deprivation and isolation, most sensory modalities are deprived approximately equally, and some schedule of constructive activity (monitoring, problem solving, etc.) is programmed during the exposure to the treatment variable. In the isolation studies the experimental setting is usually of normal room size or greater. But in these confinement studies no constructive schedule of activities was programmed for the subjects (Ss) during confinement, and the experimental chamber (APC) provided only enough room for the occupants to sit. Perhaps the greatest difference between this work and the sensory-deprivation and isolation work lay in the subject variable. Instead of a highly select small group of volunteers with high motivation and a first-hand knowledge of the reasons for the experiment, the Ss in this program represented a cross-section of armored and infantry personnel assigned by their commands to participate in experiments that, at least initially, had no meaning or relevance for them. Finally, while the results of this series of experiments may supplement the results of the sensory-deprivation work, the purposes were different. For the most part, the sensory-deprivation work was conducted to explain behavior and define performance during conditions of extreme deprivation or prolonged isolation (days or weeks) and to determine the influence of each sensory modality on the total performance of the individual. Conversely, the purpose of this program was to determine how "long-term" confinement affects performance outside the experimental chamber (APC). Behavior during the confinement period was not the main focus of attention.

Specifically, the goals of this program were:

a. To determine the effects on the performance of infantry personnel of long-term confinement in APCs.

b. To formulate procedures for maintaining combat efficiency.

c. To spell out general design recommendations, based on experimental findings, for future armored v   ies.

d. To determine the psychological and physiological limits of individuals confined in tracked vehicles.

This report summarizes the results of eight e. periments in this program. The results will be discussed as they relate to the goals of the entire program.

METHOD

Subjects

The subjects (Ss) for this program were 277 enlisted men provided by the following units:

a. Third Armored Cavalry Regiment, Ft. George G. Meade, Md.

b. First Armored Division, Ft. Hood, Texas.

c. Second Armored Rifle Battalion, 54th Infantry Regiment, Ft. Knox, Ky.

d. Fourth Battle Group, 10th Infantry, Ft. Davis, Canal Zone (for studies conducted in the Republic of Panama).

Apparatus

The apparatus used during this program consisted of the following:

The Vehicle Cross-Country Course was selected for its ruggedness as the treatment course for this investigation. This course is a permanent facility at Aberdeen Proving Ground (APG). It was designed to test the durability of vehicles over the most severe terrain features found in a natural setting.

The Obstructed-Run Course was designed to measure gross motor coordination and stamina. It was constructed in two parallel lanes, each 110 yards long, and it included four ditches ten feet wide along a 40-yard straightaway, 30 yards of staggered automobile tires, a 30-yard banked straightaway, 40 yards of staggered four-by-fours, and 30 yards of hurdles 2 1/2 feet high. There was an unobstructed area ten feet long between each series of obstructions (Figs. 1 and 2).

The Grenade-Throw Course, designed to measure eye-arm coordination, consisted simply of ten pits four feet square and a restraining line 25 yards from the center of the targets. The pits were covered with eight inches of fine sand placed there to stop the grenades on impact (Fig. 3). (The use of this course was discontinued after the fourth experiment.)

The Rail-Walking Course measured equilibrium in ten separate tests made up of one nine-foot by four-inch rail, one nine-foot by two-inch rail, and one six-foot by one-inch rail arranged in a triangular pattern (Fig. 4).

Fig. 1. SUBJECT MOVING THROUGH STAGGERED AUTOMOBILE TIRES ON THE OBSTRUCTED-RUN COURSE
(Notice that in order to clear each tire he must stay on the ball of his feet.)

The Rifle-Fire Course was designed to measure rifle accuracy. It consisted of two banks of electrically operated, remote-controlled targets. Each bank consisted of nine targets spaced at intervals of 20 feet (in the first experiment the distance between targets varied between 20 and 25 feet). The two target banks were located at points 100 yards and 150 yards from the firing line. Power and control wiring was entrenched from the target locations to the range control tower and terminated there in a control console. The experimenter had the option of selecting either automatic or manually selected "up" time. In the automatic mode, the experimenter selected "up" time (variable from one through ten seconds) and pressed a "raise" switch. Through timer and relay contacts, the chart drive -- recording hits -- was engaged, followed 0.5 second later by the target being elevated. The target remained in the raised position until the selected "up" time had elapsed. Then it lowered, and the chart drive stopped (Fig. 5). In the program's final experiment (8), this test was replaced by a rifle exercise utilizing standard known-distance procedures.

These four courses made up the combat-test battery used to assess changes in psychomotor performance as a result of confinement in maneuvering and stationary APCs.

The following apparatus was used only in the Republic of Panama:

a. Stoelting Selective Reaction Timer

The timer comprised a control box with clock, light-stimulus board, and reaction keyboard. The experimenter set a selector switch for the chosen visual stimulus (red, green, or amber light). He depressed a master key to initiate the reaction-timing cycle by starting the clock and presenting the selected light stimulus simultaneously. The S stopped the timing cycle by depressing the appropriate reaction key.

b. Stoelting Hand-Steadiness Test

This apparatus consisted of a metal plate with nine apertures decreasing in size from 9/16 inch to 2/16 inch; a wood-handled metal-tipped stylus; and a control box housing a program-timer, mechanical counter, and an on-off toggle switch.

c. Equilibrium Block

This apparatus consisted of a one-foot-long 2"x2" wooden rail, mounted diagonally on a 3/4-inch plywood base.

d. Running Course

The course had two marked lanes, each 110 yards long, over level ground, with a flagged turning point. Total length of the course was 220 yards.

Additional equipment used at varying stages throughout this program to measure environmental variables will be cited when these variables are discussed.

Ten-Foot Holes

Banked Straightaway

Change-of-Pace Ties

Low Hurdles

Fig. 2. SUBJECTS PERFORMING ON FOUR OBSTACLES MAKING UP PARTS OF THE OBSTRUCTED-RUN COURSE

Fig. 3. SUBJECTS PERFORMING ON THE GRENADE-THROW COURSE
(Notice the target boxes in the background.)

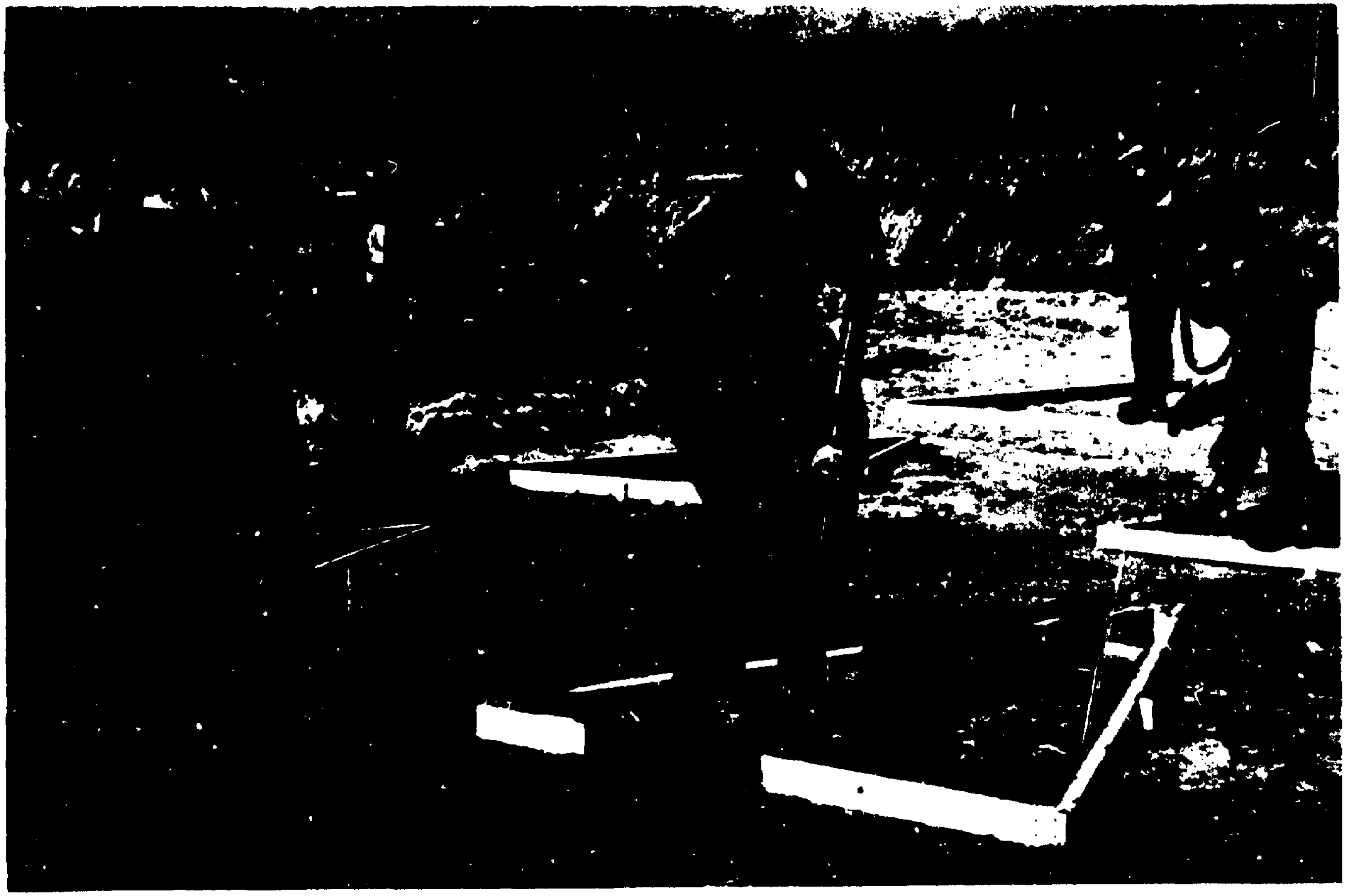

Fig. 4. SUBJECTS BEING TESTED FOR EQUILIBRIUM ON THE RAIL-WALKING TEST
(The subject in the foreground is attempting to complete the one-inch rail.)

Fig. 5. SUBJECT IN POSITION ON THE RIFLE-FIRE COURSE
(Silhouette targets appeared 100 to 130 yards to the front of the subject. Note arrow pointing to silhouette in background.)

Procedure

The general procedure followed during the course of this program is depicted in the model below:

	Tests			
	Rail-Walking	Obstructed-Run	Grenade-Throw	Rifle-Fire
Trial				
1	Practice	Practice	Practice	Practice
2	Practice	Practice	Practice	Practice
3	Practice	Practice	Practice	Practice
4	Practice	Practice	Practice	Practice
Confinement				
5	Post-Confinement	Post-Confinement	Post-Confinement	Post-Confinement

Although minor changes were made in individual studies, the procedure outlined was generally followed. On the assumption that the Ss' performance would improve gradually, trial by trial, Trials 1 through 3 were intended primarily to stabilize their performances. It was further assumed that practice would decrease intra-subject variability, thereby lending greater reliability to the measurements of performance loss after confinement. Finally, where control groups were used (pilot study), their proficiency was expected to follow the same pattern: either to increase continuously during post-confinement trials as compared to pre-confinement trials, or to remain the same.

Variations on this design were used during the investigations of the effects of repeated confinement (8, 9). The major differences in these studies involved introducing more than one confinement period.

A treatments-by-subjects design was used throughout the program. Thus each subject was his own control, eliminating inter-subject differences as a source of error. Furthermore, this method made it possible to determine the cause of observed differences between experimental conditions relatively exactly.

Before administering any test, printed instructions were read to all Ss (Appendix). After the instructions were read but before the initial trial, the Ss observed a demonstration of each test. After the demonstration, no more than two informal familiarization trials were run and were followed by the first practice trial. During the course of the program, all pre-confinement trials were run at approximately the same time of day at which the post-confinement trials were scheduled. This allowed some control of any diurnal variations in performance that accompany tasks such as those used here. In addition, it provided approximately the same daylight conditions for each trial of the Rifle-Fire test.

On the morning following the final pre-confinement trial, or at a time gauged to provide for post-confinement trial, the Ss were loaded into the APC with all personal and organizational equipment (Fig. 6). After loading, all exits were closed and sealed. The only means of communication with the outside were EE8 field telephones and the vision blocks in the commander's cupola.

During the shorter confinement periods, the drivers operated with hatches closed or with a Plexiglas hood placed over the hatch opening to restrict air flow into the crew compartment. During the longer periods the drivers' compartments were partitioned and sealed off from the crew compartment. Drivers could relieve one another and drive with hatches open, but air circulation in the remainder of the vehicle was restricted. As a further check on air circulation, all hatches were sealed from the outside with masking tape. The masking tape allowed the hatches to open under normal pressure but served to check tampering by the Ss during the confinement period.

Throughout each experiment the drivers were given a ten-minute break every hour and a 20-minute break at mealtime.

When a vehicle failed, two APCs were placed ramp to ramp and squads passed from one to the other as rapidly as possible without pausing between vehicles.

During each ten-minute break, squad leaders were required to report on the condition of their squad and the air in the vehicle was sampled. The samples were analyzed for percentage of oxygen, carbon dioxide, carbon monoxide, and explosive gases. Ambient temperature and relative humidity were checked each hour with an electric hygrometer.

Before and after each experiment all Ss were given a thorough physical examination to screen out Ss who might have been adversely affected by the severity of the environment and to detect any change among all Ss attributable to the treatment.

At the end of the confinement period, the Ss were unloaded in the test-course area and immediately run through the post-confinement trials.

One experiment in this program was conducted in the Republic of Panama during Operation Swamp Fox II from August to October 1962. The site necessitated an extreme change in the measuring tools used, but major changes in the standard test criteria were avoided. Where possible the same measurements were taken, using test courses or apparatus reduced in size and complexity as dictated by portability requirements and terrain limitations. The procedure remained identical in most instances, with one major exception: introducing repeated confinement as an experimental variable. The rationale for this change is discussed in following sections of this report.

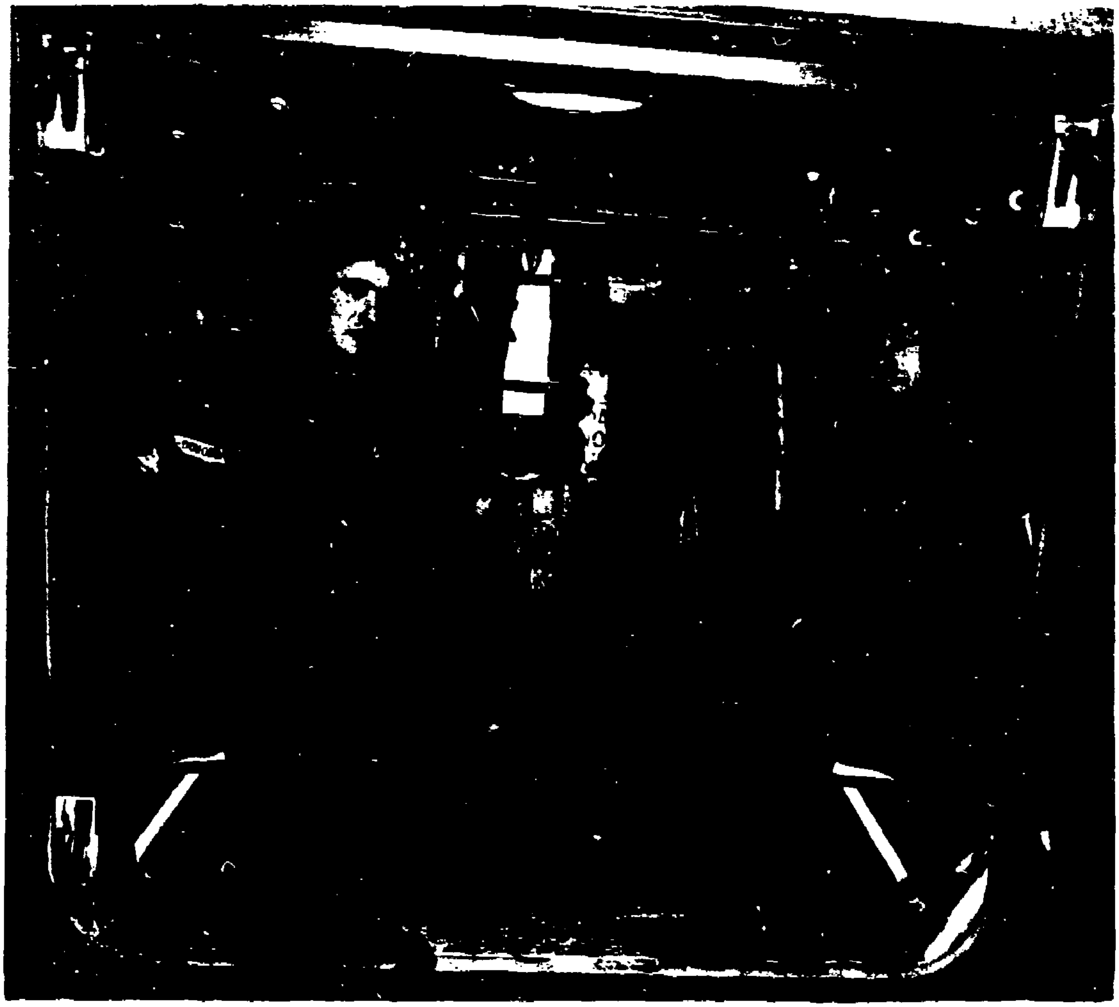

Fig. 6. EXPERIMENTAL VEHICLE INTERIOR AT START OF CONFINEMENT SESSION
(Equipment has been stowed in front of troop compartment, under seats, and along sidewalls of vehicle.)

RESULTS AND DISCUSSION

Rail-Walking Test

Both time and distance scores were obtained from the Rail-Walking test. The maximum distance score was represented by a weighted value of 153. This distance score was based on feet traversed per rail, thus the maximum attainable distance score for each rail was:

27 feet -- 4-inch rail

27 feet -- 2-inch rail

18 feet -- 1-inch rail

These distances were converted into weighted scores through the multiplication of 1, 2, and 4 times the distance traveled on the 4-, 2-, and 1-inch rails respectively, i.e.,

Rail	Distance Traveled x *f** = weighted score
4	27 x 1 = 27
2	27 x 2 = 54
1	18 x 4 = 72
	153

This arrangement gave the most difficult or narrowest rail the highest value. The time scores were based on the total elapsed time on each rail.

Summary data for each of the experiments involving a single confinement period are presented in Table 1.

* *f* = weighting factor

TABLE 1

Rail-Walking Test -- Summary Data

		Time					Distance				
Confinement		Mean	SD	MD[a]	F	N	Mean	SD	MD[a]	F	N
4 hr.	Pre	63.5	12.6	+2.7	1.14	36	146.7	11.5	-17.1	22.42**	36
	Post	66.2	13.1				129.6	25.9			
8 hr.	Pre	58.0	9.1	+4.2	10.47*	20	149.0	7.5	- 8.7	4.41*	20
	Post	62.2	9.6				140.3	18.7			
12 hr.	Pre	64.5	12.7	+4.4	8.56*	30	139.3	13.9	- 3.5	1.53	30
	Post	68.9	14.4				135.8	14.3			
12 hr.	Pre	77.5	13.4	+3.1	3.17	37	131.2	14.8	- 0.1	--[b]	37
	Post	80.6	10.8				131.1	16.2			
24 hr.	Pre	64.0	9.7	+2.9	--[b]	21	135.4	20.6	- 7.9	--[b]	21
I	Post	66.9	8.9				127.5	26.2			
24 hr.	Pre	59.6	10.9	+ .3	--[b]	38	139.8	15.5	-13.3	18.27**	38
II	Post	59.9	10.4				126.5	16.5			

* $p \leq .05$
** $p \leq .01$
a Difference between pre- and post-confinement means.
b No F test was done for these data.

Obstructed-Run Test

Time and error scores were recorded during the Obstructed-Run test. The time score was total time taken to complete the course, and the error score was actual number of obstacles missed. The time score served as an index of stamina, while the number of obstacles missed was used as an index of locomotor coordination.

Mean time and error scores are presented in Table 2.

Rifle-Fire Test

The Rifle-Fire test yielded scores based only on the total number of hits scored out of the number fired. During the first experiment in this program each S fired a total of 18 shots; in subsequent tests each S fired 27 shots. Mean performance levels are given in Table 3. To present an accurate picture of performance during each of the experiments, mean levels are given as percentages of the total number of shots fired.

Inspection of Tables 1, 2, and 3 reveals a decrease in proficiency for each of the criterion tasks as measured by the difference between pre- and post-confinement mean scores. For the most part, except as cited in the tables, analysis of variance techniques defined these differences as statistically significant. (For a more detailed presentation of the statistical analyses see References 2 through 9.) However, contrary to the original hypothesis, performance decrements were not directly related to length of confinement. In fact, with one exception, the consistently larger decrements occurred after the shorter confinement periods. It appears that the critical factor was not the duration of confinement, but confinement itself. The one exception occurred during the follow-up investigation of a 24-hour confinement period.

During the first investigation of 24-hour confinement, voluntary loss of Ss during the period of confinement was a major problem. Approximately 50 percent of the experimental population was lost -- thus the power of the statistical test was also reduced. Most of the losses were due to claims of illnesses and injury that were not substantiated by medical report. To avoid such losses during the follow-up investigation, the Ss' company officers were present at the test site not only during practice trials but throughout the confinement session. The effect of their presence on the experimental population is evident in the sample size reported for each test. The loss of Ss was held to a minimum, and losses that were experienced were based on pre-experimental medical reports. The major effect of reducing these losses was to provide results most nearly resembling those witnessed after shorter periods of confinement. While the decrement did not increase with longer confinements, neither did it decrease.

TABLE 2

Obstructed-Run Test -- Summary Data

Confinement		Time Mean	Time SD	Time MD[a]	Time F	Time N	Error Mean	Error SD	Error MD[a]	Error F	Error N
4 hr.	Pre	71.5	8.9	+5.8	12.51**	30	4.7	2.8	+2.9	13.23**	32
Dynamic	Post	77.3	10.2				7.6	6.0			
8 hr.	Pre	59.6	5.9	+5.9	21.41*	19	0.7	1.6	+1.6	15.09**	19
Dynamic	Post	65.5	7.1				2.3	2.6			
12 hr.	Pre	64.5	12.7	+4.4	12.83*	35	1.7	1.9	+2.7	16.47**	35
Static	Post	68.9	14.4				4.4	2.9			
12 hr.	Pre	62.3	8.5	+5.6	10.81*	34	4.9	5.6	-0.5	--[b]	34
Dynamic	Post	67.9	11.3				4.3	3.0			
24 hr. I	Pre	62.1	8.2	+1.2	--[b]	23	3.4	1.3	+1.4	--[b]	22
Dynamic	Post	63.3	7.7				4.8	3.6			
24 hr. II	Pre	59.8	6.1	+4.8	11.63	38	2.2	1.7	+4.4	12.35**	39
Dynamic	Post	64.6	11.1				6.1	6.7			

* $p \leq .05$

** $p \leq .01$

[a] Difference between pre- and post-confinement means.

[b] No F test was done for these data.

The 24-hour follow-up also substantiated two phenomena mentioned in earlier studies: (a) an adaptation phenomenon and (b) a self-selection process. Adaptation is the process by which certain individuals in the experimental population warded off any possible ill effects of confinement, although they found the environment noxious and more than somewhat distracting, and emerged nearly as effective as they were during pre-confinement testing. Self-selection is the process by which many Ss used imagined illnesses and injuries as a means of escaping from confinement. It was observed in previous reports that these two groups were readily identifiable. Individuals who tended to adapt showed little, if any, decrement, but those who were prone to escape the treatment sessions were conspicuous by their absence during post-confinement tests. When they did appear for testing, they showed consistently large decrements. However, evaluation of the results of each study suggests that self-selection may be transient in nature; if the individual prone to self-selection were forced to remain in the vehicle for a long period of time on more than one occasion he might also adapt and show a post-confinement performance level approximating his pre-confinement level. To check the validity of this assumption, two investigations explored the effects of repeated confinement on performance.

The first of these two studies was conducted in the Republic of Panama during the summer and fall of 1962. During this study the test battery was modified for maximum portability and ease of administration; thus the tests used differed drastically in appearance from those used at APG. However, face validity would indicate that each test used in Panama was highly related to the standard combat test battery employed throughout the program, and, though differing in technique, measured the same components of psychomotor behavior.

APG Tests	Psychomotor Components	Republic of Panama Tests
1. Rifle Fire	Eye-hand coordination	Choice Reaction Time -- Hand-Steadiness Test
2. Obstructed Run	Stamina	220-Yard Run
3. Rail Walking	Equilibrium	Equilibrium Block

The tests used in the Republic of Panama are described below.

TABLE 3

Rifle-Fire Test -- Summary Data

Confinement		Mean	SD	MD[a]	F
4 hr. Dynamic	Pre	50.6	18.6	13.7	17.88**
	Post	36.9	15.2		
8 hr. Dynamic	Pre	Accuracy levels too low to merit analysis.			
	Post				
12 hr. Static	Pre	13.2	--	.20	--[b]
	Post	13.4	--		
12 hr. Dynamic	Pre	36.8	14.9	1.1	not significant
	Post	37.9	19.4		
24 hr. I Dynamic	Pre	57.1	9.8	5.4	not significant
	Post	51.7	21.8		
24 hr. II Dynamic	Pre	62.1	19.1	8.1	7.76*
	Post	54.0	21.3		

* $\underline{p} \leq .05$

** $\underline{p} \leq .01$

[a] Difference between pre- and post-confinement means.

[b] No $\underline{F}$ test was done for this condition because $\underline{N}$ was too small.

Choice Reaction Time

During this test Ss were shown one of three visual stimuli (S1, S2, S3) and required to respond by pressing the appropriate response key (R1, R2, R3) respectively. The experimenter began the reaction timing cycle by pushing a master key on the control box, simultaneously starting the clock and presenting a pre-selected light stimulus. The timing cycle stopped when the S depressed the appropriate response key. Elapsed time measured the S's choice reaction time. The stimuli were presented in random order for 15 trials in each session. Table 4 presents the summary data.

TABLE 4

Choice Reaction Time -- Summary Data[a]

	Trials				
	Pre-Confinement	Post-Confinement			
	I	II	III	IV	V
Mean	.53 sec.	.65 sec.	.49 sec.	.54 sec.	.46 sec.
SD	.09	.10	.08	.08	.06
MD[b]	--	+.12	-.04	+.01	-.07

[a] No significant differences.

[b] Difference between pre- and post-confinement means.

Hand-Steadiness Test

In this test the S used his preferred but unsupported hand to hold a metal stylus in a series of apertures of decreasing diameters while trying to avoid touching the side. A single trial lasted a maximum of 20 seconds, but the trial ended immediately, and an error was scored, if the stylus touched the side of the hole. The experimenter recorded the final point of error-free performance -- the smallest hole at which the S did not make an error -- and used it as the performance criterion. Table 5 summarizes the data.

TABLE 5

Hand-Steadiness Test -- Summary Data

	Trials					
	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Mean	6.50	3.90	4.80	4.60	4.30	5.40
SD	1.20	1.51	1.72	2.20	1.95	1.74
MD[a]	--	-2.60*	-1.70*	-1.90*	-2.20*	-1.10

* $p \leq .05$

[a] Difference between pre- and post-confinement means.

Equilibrium Block

Using only the preferred foot, and with both eyes closed, Ss balanced on a rail two inches wide and one foot long. Each S got three trials. A trial ended when the S lost his balance, opened his eyes, or touched his other foot to the rail. Total elapsed time on the block was the test criterion. Table 6 summarizes the results.

TABLE 6

Equilibrium Test -- Summary Data

	Trials					
	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Mean	.19 sec.	.08 sec.	.11 sec.	.09 sec.	.11 sec.	.19 sec.
SD	.09	.02	.07	.04	.08	.11
MD[a]	--	-.11*	-.08*	-.10*	-.08*	.00

* $p \leq .05$

[a] Difference between pre- and post-confinement means.

Running Speed

Subjects were told to run the 220-yard course as rapidly as possible. The experimenter recorded time elapsed from start to finish. Table 7 presents summary data.

TABLE 7

220-Yard Run -- Summary Data

	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Mean	.642 sec.	.767 sec.	.722 sec.	.716 sec.	.682 sec.	.678 sec.
SD	.06	.11	.06	.07	.10	.07
MD[a]	--	+.125*	+.080*	+.074*	+.040	+.036

* $p \leq .05$

[a] Difference between pre- and post-confinement means.

The results of the investigation conducted in the Republic of Panama indicated that, when the infantryman was confined to the APC repeatedly over a number of days and tested at the end of each confinement session, his performance showed the largest decrement after the first confinement period, with smaller and smaller decrements after later confinements; eventually his performance level equaled or at least approximated his pre-confinement level. However, closer examination disclosed that these results could not be compared directly with results from previous studies, since the measuring tools had been modified, repeated confinements had been introduced, and the sample size was smaller.

To allow more adequate comparison of single vs. repeated confinement periods as a major variable, a second study was conducted at APG to investigate the effects of repeated confinement. This investigation used the test battery that had been developed for this program at APG. The results of this more recent study, presented in Tables 8, 9, and 10, supported those of the investigation conducted in the Republic of Panama. It is equally noteworthy that the decrements after the initial confinement period approximated those that had been reported for earlier studies.

Fig. 7. RESTRICTIONS IMPOSED BY CENTER BUCKET SEATS
(The position of the cente. bucket seat severely restricts the movement of personnel sitting opposite it. Note the position of the passenger's knees on the left as they overlap the knees of the passenger occupying the bucket seat.)

TABLE 8

Rail-Walking Test -- Summary Data
(Repeated Confinement)

	Trials					
	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Time						
Mean	133.14	111.14	120.25	124.64	120.57	131.71
SD	15.8	24.1	23.6	7.9	17.8	15.0
MD[a]	--	-22.00**	-12.89	-8.50	-12.57	-1.43
Distance						
Mean	119.25	117.96	120.75	121.00	119.82	119.36
SD	13.9	14.3	17.7	21.0	21.9	16.6
MD[a]	--	-1.29	+1.50	+1.75	+.57	+.11

** $p \leq .01$

[a] Difference between pre- and post-confinement means.

In the early investigations in this program, certain factors seemed to contribute to the observed decrements in performance. The most obvious was body cramping imposed by the vehicle configuration and the resulting loss of circulation in the lower body. Subjects occupying the seats directly opposite the bucket seats in the middle of the compartment registered the most vociferous complaints (Fig. 7). They complained that the rim of the bucket seats cut into the front of their knees. Our attempts to correct this deficiency by altering body position were frustrated by the crowding of the vehicle.

Fig. 8. POSITION OF ACCESS PANEL
(Arrow points to general area where latches were removed to prevent their cu.ting into the passengers' shoulders.)

TABLE 9

Obstructed-Run Test -- Summary Data
(Repeated Confinement)

	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Time						
Mean	104.38	117.57	108.62	110.04	107.50	103.71
SD	8.86	13.05	12.48	16.33	13.59	11.33
MD[a]	--	+13.19**	+4.24	+5.66	+3.12	-.67
Error						
Mean	2.81	6.85	4.19	2.62	2.62	2.35
SD	2.26	3.47	2.74	2.58	1.87	2.59
MD[a]	--	+4.04**	+1.38	-.19	-.19	-.46

** $p \leq .01$

[a] Difference between pre- and post-confinement means.

Secondly, the backrest cut into the small of the back and the kidney area, causing a great deal of discomfort, particularly when riding over rough terrain. It was recommended that the backrest should be approximately four inches higher. On the left side of the carrier, facing forward, there is a removable panel which provides access to the fuel tanks in the carrier's sidewall. Passengers sitting in front of this panel complained that the latches irritated the shoulder and neck area (Fig. 8). During experimentation these latches were removed, but if they are necessary they might be relocated and/or recessed. The radio rack mounted in the left sidewall protrudes beyond the wall at the left passenger bench's backrest (Fig. 9). It prevents passengers in the first three positions on this seat from sitting comfortably. The edges of the rack irritate the passengers' backs and necks and keep them from using the backrest. One S's scalp was lacerated by the corner of the rack when the vehicle suddenly lurched sideways on the cross-country course.

Fig. 9. POSITION OF RADIO RACK (UPPER RIGHT) IN RELATION TO BODY POSITION OF PASSENGER
(Vertical bar support of rack was responsible for injury to one subject.)

TABLE 10

Rifle-Fire Test -- Summary Data
(Repeated Confinement)

	Trials					
	Pre-Confinement	Post-Confinement				
	I	II	III	IV	V	VI
Mean	17.8	13.8	15.5	15.9	16.3	18.0
SD	4.08	4.80	5.00	5.41	4.83	4.07
MD[a]	--	-4.0**	-2.3	-1.9	-1.5	+.2

** $p \leq .01$

[a] Difference between pre- and post-confinement means.

Throughout the program there was about a 20 - 30 percent incidence of nausea on first-time exposure to the confinement situation. The apparent causes of nausea were elicited by interviews. Causes mentioned, in addition to common motion sickness, were food with a high fat content, the sight of someone else suffering from nausea, and air pollution (caused primarily by gasoline fumes). One case of nausea was associated with a severe claustrophobic reaction. This case is discussed in detail in Human Engineering Laboratories Technical Memorandum 17-60 (3). With repeated exposure to the confinement situation, the incidence of nausea was drastically reduced, suggesting that, with the possible exception of those people who are extremely susceptible to motion sickness, individuals tend to acclimate to this environment.

Generally, temperature and humidity posed no problem. With only a single exception, the temperatures in the vehicles did not affect the <u>Ss</u>. In one instance, during a 12-hour confinement in stationary vehicles, the temperature became a critical factor, eventually necessitating the abortion of one phase of the experiment. Figures 10 and 11 summarize the environmental conditions in the two vehicles in use on that day. One vehicle was stationary with the engine idling, while the other vehicle's engine remained off. During the early part of the day the temperatures in both vehicles were decidedly higher than ambient. As the day progressed, the difference between interior temperature and ambient temperature increased, reaching its peak at about 1200 hours. More important, though, was the difference between interior relative humidity (RH) and ambient RH. The ambient RH decreased steadily

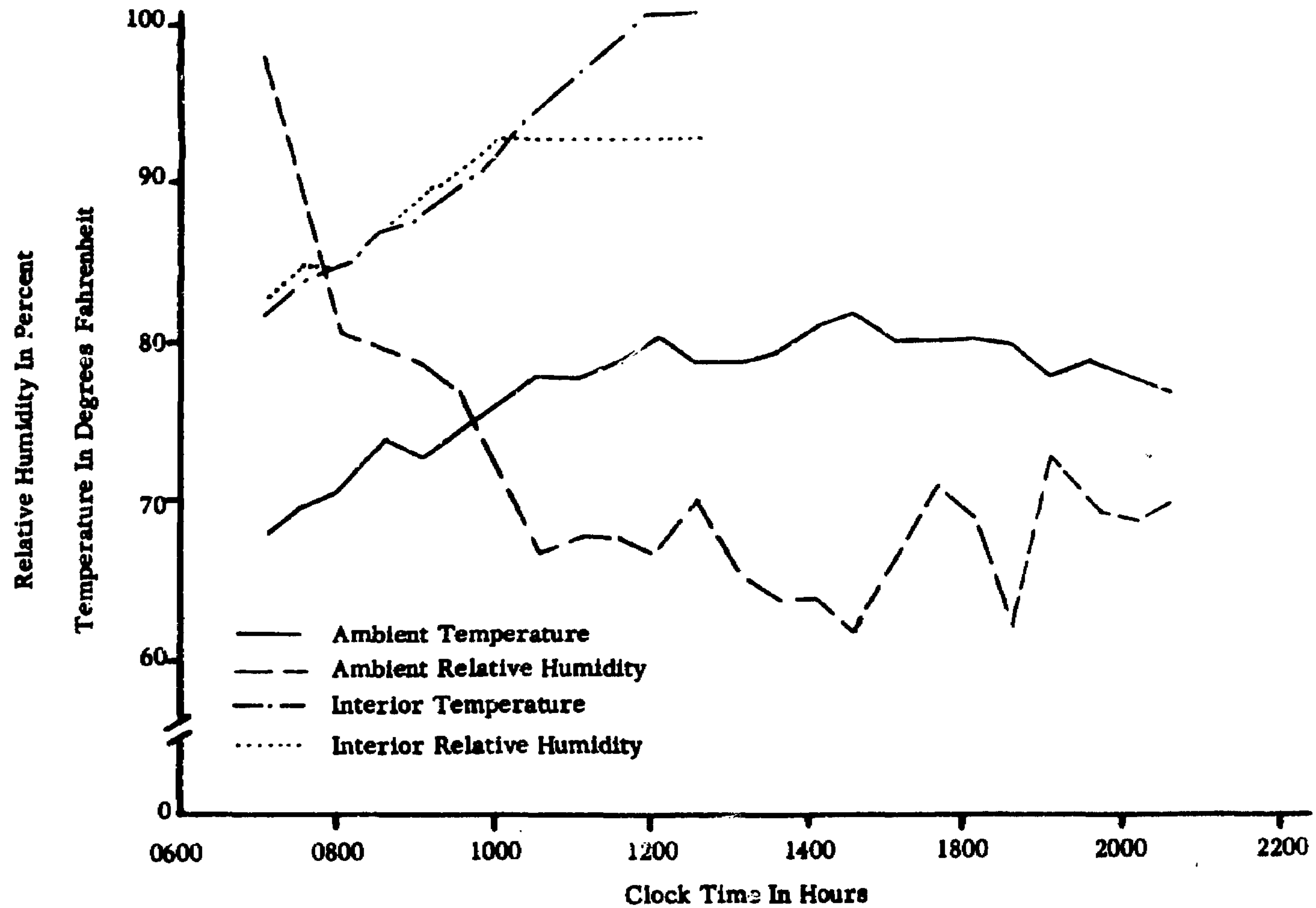

Fig. 10. ENVIRONMENTAL CONDITIONS IN VEHICLE I (ENGINE OFF) DURING 12-HOUR (STATIC) CONFINEMENT STUDY

throughout the day. The RH in the vehicle with its engine idling (Fig. 11) showed the same general trend, but RH in the vehicle with its engine off rose steadily from 80 percent to 94 percent in less than six hours. At this point the temperature of the vehicle was 101° F. The combination of temperature and RH yielded an Effective Temperature (ET) of approximately 100°. To avoid any possibility that prolonged exposure to such extreme environmental conditions might harm the Ss, the engine-off condition was cancelled.

The restrictions and discomforts imposed on the passengers by the layout of the vehicles probably contributed significantly to the decrements observed in the early studies of this program. In addition to the design deficiencies noted previously, lack of adequate stowage space presented quite a problem. While there is a prescribed Table of Organization and Equipment (TO&E), the unit commander is allowed a number of departures from this TO&E. Thus equipment in the vehicle will vary from unit to unit. This equipment may include many combinations of the following items:

a. combat pack

b. cargo pack

c. duffel bag

d. bedroll

e. additional personal equipment

f. individual arms and equipment

g. crew-served arms

h. organizational equipment

i. interior vehicle mounted equipment

The vehicle provides too few tie-downs and too little space for this equipment; consequently, it must be stowed in the aisle. This stowing further restricts the movements and increases the cramping of the crew members, who would be extremely uncomfortable with even less equipment. With longer stays in the vehicle, the equipment became more and more a nuisance as it shifted about and cluttered the floor (Fig. 12). At the conclusion of the confinement, it blocked egress from the vehicle so much that, in one instance, a squad of 11 men took approximately three minutes to dismount. In the later studies on repeated confinement, Ss began to work out arrangements to keep equipment off the floor and out of the way, but when they left the vehicle many of them had no idea where their own equipment was. When firing exercises were scheduled, Ss had to be warned about 10 minutes before unloading so they could locate all of their equipment.

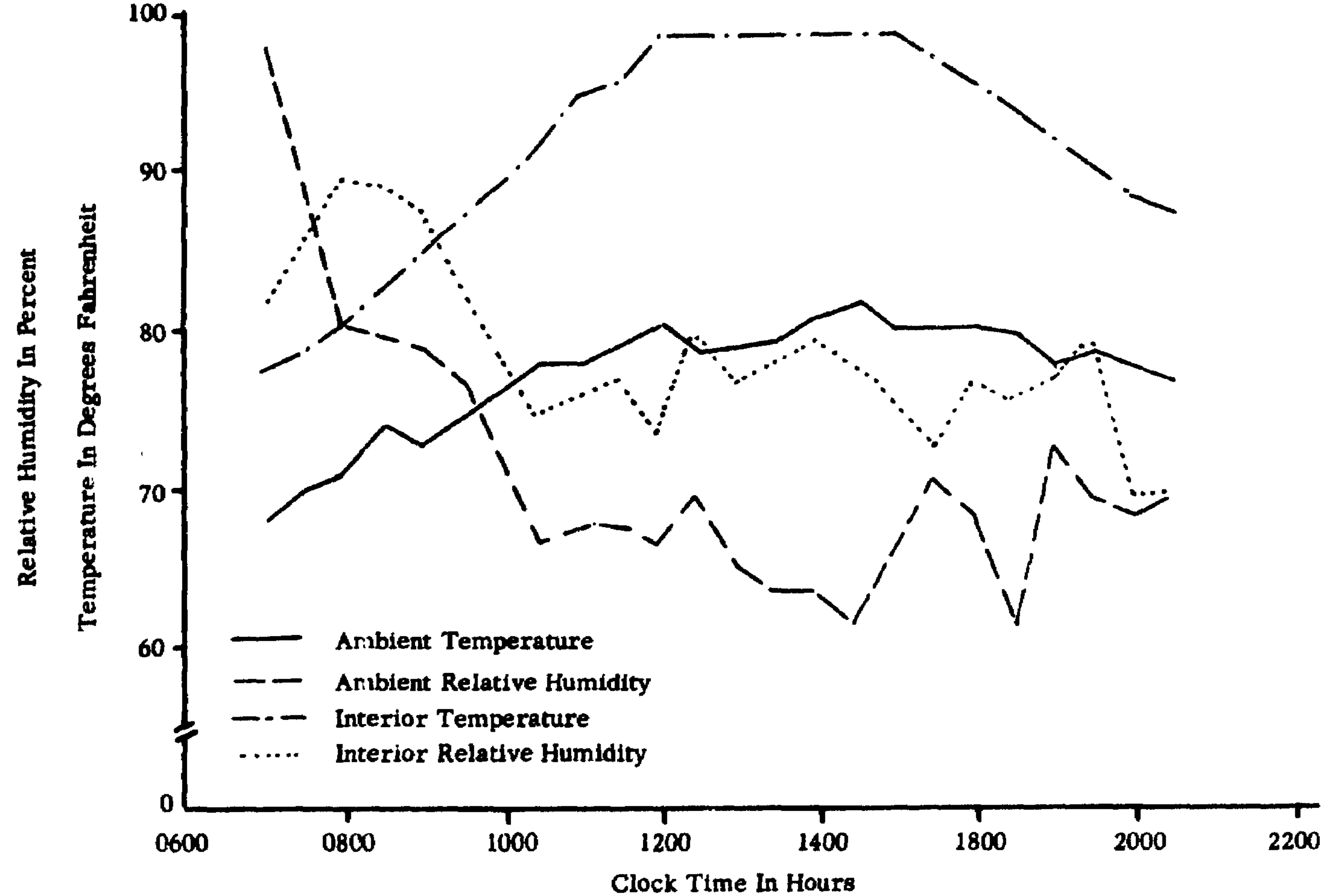

Fig. 11. ENVIRONMENTAL CONDITIONS IN VEHICLE II (ENGINE IDLING) *DURING 12-HOUR (STATIC) CONFINEMENT STUDY*

Another major environmental problem was water vapor collecting on the interior surfaces of the vehicle. The exact cause of this condensation is unknown, but at relatively low temperatures -- 40° F. was encountered in a vehicle during one investigation (6) -- the atmospheric pressure needed to condense water vapor in the air is drastically reduced. The condensation may, therefore, become exaggerated in the experimental environment, where the buttoned-up vehicle provides little ventilation to remove water vapor from the air. During the periods of maximum condensation (2200 to 0600 hours), passengers found it difficult to rest against the sidewalls, for clothing became wet and uncomfortable. The water that collected on the ceiling dripped, wetting clothing and equipment. Arms and other equipment began to rust after continued exposure. The commander's vision block fogged up, and it is possible that if the driver had been operating in the buttoned condition, his vision would have been impaired so severely that continued operation would have been extremely hazardous.

Fig. 12. EXPERIMENTAL VEHICLE AFTER 24 HOURS OF CONTINUOUS OPERATION
(Note damp condition of duffel bags and other equipment.)

CONCLUSIONS

The results of this program support the following conclusions:

a. Because this series of studies could not fully simulate the extreme conditions which might occur in battle -- for example, the driver's hatch was open, allowing better vision and ventilation -- the results must be interpreted cautiously. The following conclusions apply to men under conditions like the ones studied. If there are major changes in variables like duration of confinement, or if new variables are introduced, confinement may have drastically different effects than reported here.

b. As defined by the confinement durations considered under this program, the effects of long-term confinement on the performance of infantry personnel are relatively transient.

c. While decrements may be demonstrated for single periods of confinement, the decrements become smaller and eventually seem to vanish after repeated confinements.

d. If infantry tasks may be analyzed into the skills measured in this investigation, then any detrimental effects attributable to single or infrequent confinements may be offset through repeated practice of the tasks to be performed and through repeated exposure to the confinement situation before deployment.

e. Although this series of studies dealt with confinement as a single complex variable, without even attempting a human factors evaluation of the vehicle, it did become obvious that the vehicle design itself has deficiencies. While it is difficult to modify a vehicle during production, a thorough human factors analysis during the concept phase would have eliminated many of these deficiencies without necessarily increasing the vehicle's cost appreciably. Therefore it is recommended that, in the future, human engineering should play an integral part during the concept stages of developing vehicles like this.

REFERENCES

1. Edwards, A. L. Experimental design in psychological research. New York: Rinehart and Co., Inc., 1960.

2. Hicks, S. A. The effects of four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A pilot study. Technical Memorandum 3-60, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., March 1960.

3. Hicks, S. A. The effects of eight hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study II. Technical Memorandum 17-60, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., November 1960.

4. Hicks, S. A. The effects of twelve hours confinement in [illegible]atic armored personnel carriers on selected combat relevant skills: Study III. Technical Memorandum 1-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., February 1961.

5. Hicks, S. A. The effects of twelve hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study IV. Technical Memorandum 2-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., May 1961.

6. Hicks, S. A. The effects of twenty-four hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study V. Technical Memorandum 23-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., November 1961.

7. Hicks, S. A. The effects of twenty-four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A follow up. Technical Memorandum 7-62, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., June 1962.

8. Hicks, S. A. The effects of repeated confinement on the performance of men in a hot-wet climate. Technical Memorandum 7-63, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., January 1963.

9. Hicks, S. A. The effects of repeated confinement on the performance of men in a temperate environment. Technical Memorandum 11-64, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., August 1964.

10. Lindquist, E. F. Design and analysis of experiments in psychology and education. Boston: Houghton Mifflin Co., 1953.

APPENDIX

INSTRUCTIONS FOR ADMINISTERING COMBAT TEST BATTERY

TEST BATTERY RATIONALE

The individual tests making up this battery were devised or selected with the job of the infantryman in mind. An attempt has been made to select a series of tests that will give an accurate picture of the losses encountered in critical behavioral measures that could hinder the performance of the infantryman and the infantry squad most significantly. The tests to be used and their behavioral counterpart are listed below:

Tests	Behavioral Measure
1. Rifle Fire	Response time and hand-arm steadiness
2. Grenade Throw	Eye-arm coordination
3. Obstructed Run	Gross muscular coordination and stamina
4. Rail Walking	Equilibrium

TESTS

RIFLE-FIRE TESTS

Equipment

1. Eighteen M31A1 Trainfire Target Mechanisms
2. .30-Cal. M-1 Rifles
3. .30-Cal. Ball Ammunition
4. Electronic Timer
5. Multi-Channel Recorder

Instructions

First Day

I am ______________ of __________________. This morning we will begin a series of tests designed to determine your ability to get off a fast, well-aimed rifle shot at targets placed at varying ranges and visible for only short periods of time (show targets). As you can see, there are two targets in each lane; however, only one target will be visible at any one time. Your task will be to fire one and only one shot at each target as they are presented. Are there any questions?

You will lock and load on my command. After the first clip of ammunition is expended, you will reload and continue firing until the last target is presented.

After all of the targets have been presented, you will unload and lock your weapons and wait for clearance from the Range Safety personnel. Do not leave the firing line until you have been given clearance. If you have any leftover ammunition, hold onto it until it is collected. Are there any questions?

Remember, this is a test of your speed <u>and</u> accuracy with your weapon. (Give fire command below.)

1. Lock and load.

2. Ready on (right, left) firing line.

3. You may commence firing.

Second and Third Day

Good morning. This morning each of you will go to the same lane you fired from yesterday.

The procedure today will be the same as it was yesterday. Remember, fire only one shot on each target presentation. Are there any questions? (Give the fire command.)

Fourth Day (Instructions will be given by Officer or NCO in charge of APC.)

This morning we will ride to the rifle range in an armored personnel carrier. When we mount the carrier, men numbered 1 through 5 will sit on the left side of the carrier behind the driver; 6 through 9 will sit on the right side; 10 and 11 will occupy the seats in center of the carrier. When we dismount you will stay in numerical order. Number 1 man will be on the left flank, and number 11 man on the right flank. You will double time to the firing line, take up your positions, pick up the ammunition placed at your stations, and await the command to load and fire. Are there any questions? (Officer or NCO in charge will check seating inside APC to make certain all men are in their correct seats.)

GRENADE-THROW TEST

Equipment

1. Fifty-four practice grenades (inert)
2. Ten four-foot-square target pits

Instructions

Good morning. I am ______________ of ____________________. This morning we will begin a test to measure your accuracy with hand grenades. Your task here will consist of simply throwing the six grenades at your station into the pit directly in front of you. Remember, this is a test of accuracy. Throw as rapidly as you can without losing accuracy.

OBSTRUCTED-RUN TEST

Equipment

1. Course 220 yards long, five feet wide
2. Used automobile tires

3. Hurdles two feet high

4. Railroad ties

5. Stopwatches

Instructions

Good morning. I am _______________ of _____________________. This morning we will begin a series of tests to determine your overall coordination. In front of you are three identical courses. Each course has the same type and number of obstacles. Your task will be to run the length of this course as fast as you are able.

The first section of the course is marred by a group of staggered tires. In running through this section, you must step in each tire. The second section of the course consists of a group of hurdles which you are to jump. Try not to knock any of the hurdles down. Following the hurdles will be a group of ditches which you are to jump. Do not go around the ditches. If you do not make the jump over any one ditch, climb out and continue on to the next one. The fourth section is merely a banked straightaway. You are to run over this section as fast as you can. Finally you will run into a group of railroad ties. The distance between these ties varies. You are to step from one to another as rapidly as you can without missing one. Are there any questions?

RAIL-WALKING TEST

Equipment

1. Rails

   a. 9 ft. long x 4 in. wide

   b. 9 ft. long x 2 in. wide

   c. 6 ft. long x 1 in. wide

2. Tape measure

3. Stopwatches

Instructions

Good morning. I am ______________ of ___________________. This morning you will begin a task designed to test your sense of balance. In front of you are three rails arranged in triangular form. The rails are numbered 4, 2, and 1.

Starting at the rail marked 4, your task will be to walk across the rail in a heel-to-toe manner (Demonstrate). If your foot comes off the rail at any time or you do not make contact between heel and toe, you must go to the beginning of that rail and start again. When you have walked across the 4 rail three times you will move to the 2 rail where you will follow the same procedure, and finally you will move to the 1 rail. The same procedure will be followed here. Are there any questions?